Story by Kathy Wythe

Can't have one without the other

Water and energy are interdependent

Just as Frank Sinatra once sang about love and marriage, when it comes to water and energy, "You can't have one without the other." Water is needed to produce most energy, and energy is needed to develop and use water.

Water is used to extract and process oil, gas, and other fuels, and is an integral part of electric-power generation. Energy, in turn, is needed to pump, treat, heat, and move water, and extract "new" water from desalination, reuse, and other sources.

As the United States develops new energy sources to replace imported petroleum and natural gas, the demand for water to produce these energy sources will grow significantly. And as the population grows, so does the need for more water and energy.

With the increased need for both, this water and energy nexus or interdependence is beginning to capture attention of policy makers and researchers throughout Texas and the nation.

"Water and energy are the two most fundamental ingredients of modern civilization," wrote Dr. Michael Webber in a *Scientific American* article in October 2008. Webber is an assistant professor of mechanical engineering at the University of Texas and associate director of the Center for International Energy and Environmental Policy. "Without water, people die. Without energy, we cannot grow food, run computers, or power homes, schools, or offices."

In an interview, Webber said: "We use a lot of energy for water and we use a lot of water for energy, so constraints in one become constraints in the other. If we don't have enough energy in some situations, we might not have enough water, and if we don't have enough water, we might not have enough energy. These interconnections or relationships present important opportunities, but they also present vulnerabilities or constraints."

David Burnett, director of technology for the Global Petroleum Research Institute within Texas A&M University's Department of Petroleum Engineering, agreed.

"Two of the most critical problems facing Texas, the United States, and indeed the world, are providing adequate energy and ensuring adequate clean water resources for society and doing so in a cost-effective and environmentally responsible manner," he wrote in a white paper on water and energy.

After agricultural production of food, feed, and fiber, energy withdraws the largest amount of freshwater in the United States, accounting for nearly half of all freshwater withdrawals, although not all the water is consumed.

"Texas represents a significant part of that use," Burnett said. "Such technologies as coal to electricity, coal to liquid, coal to hydrogen, natural gas to electricity, natural gas to liquids, nuclear, biofuel feedstocks, biofuel refining, oil production, oil refining, oil and gas petrochemicals all require copious amounts of water."

Recognizing the growing demand for both energy and water, in 2004 the House and Senate Subcommittees on Energy and Water Development Appropriations asked the Department of Energy for "a report to Congress on the interdependency of energy and water focusing on threats to national energy production resulting from limited water supplies…"

The resulting report, *Energy Demands on Water Resources* published in 2006, gave an overview of the connections between energy and water, identified concerns regarding water demands of energy production, and discussed science and technologies to address water use and management in the context of energy use and production.

The report recommended the federal government collaborate with regional and state agencies, as well as with industry and other stakeholders, on energy and water resource planning. The report added that science- and system-based natural resource policies and regulations need to be developed, as do energy-water infrastructure synergies such as coordinated infrastructure development.

In 2005 the Department of Energy began developing a National Energy-Water Science and Technology Roadmap "to establish a long-range research, development, and demonstration program to support the efficient use of water and energy resources and sustainable and cost-effective future energy production and electric power generation in the U.S." To date the final Roadmap report is not published.

In March 2009, U.S. Senators Jeff Bingaman of New Mexico and Lisa Murkowski of Alaska introduced a bill, titled *Energy and Water Integration Act of 2009*. The bill would authorize several studies to analyze water use in the production of transportation fuels and electricity, as well as other mechanisms to improve the understanding of the nexus between energy and water, according to a Murkowski news release. The bill would also direct the Department of Energy to complete the Roadmap.

For Webber, the recommendation of having collaboration or integration of water and energy planning into one planning process is key.

"The most important thing is to recognize the relationship of water to energy," Webber said, "and integrate that relationship into policy making to have a more integrated approach. We need to have water and energy planners sitting together, making decisions together."

"Many people are concerned about the perils of peak oil – running out of cheap oil," Webber wrote in the *Scientific American* article. "A few are voicing concerns about peak water. But almost no one is addressing the tension between the two: Water restrictions are hampering solutions for generating more energy, and energy problems, particularly rising prices, are curtailing efforts to supply more clean water."

On the state level, this need for coordination of energy and water planning is beginning to be discussed.

In September 2008, the Texas Senate Committee on Natural Resources had a hearing that in part focused on the energy-water nexus. During the meeting, Sen. Kip Averitt said he would like to see energy planning handled in much the same way as water planning is done by the Texas Water Development Board. ⇨

"I wish this state had some vision for energy like we do for water; that way it would make your job [the Texas Water Development Board] a lot easier and more effective if we had some kind of hint of what is going to happen in the future," he said.

That vision is Texas' state water plan, updated every five years, which provides water use projections, water availability, and water management strategies to meet state's water estimation needs.

For the Texas Water Development Board, the energy-water nexus becomes a reality when the board is planning for enough water to meet the state's electricity demands.

"The issue is, with the increase in electric demand, we are going to see increases in water used to produce electricity," said Carolyn Brittin, deputy executive administrator in charge of water resources planning and information for the Texas Water Development Board.

Brittin testified at the September 2008 natural resources committee meeting on the incorporation of steam-electric water demands in state and regional water planning. She also presented results from the study, *Water Demand Projections for Power Generation in Texas*, conducted by the University of Texas' Bureau of Economic Geology.

Brittin agreed that having more knowledge of electric and other energy demands would help the board in its water planning. When the state water plan is updated every five years, she said, "We look for changed conditions and adapt the process to that. If we get better information on power demands in the next cycle, we will incorporate that in the planning process.

"At the end of previous regional water planning in 2006, some water providers came to the board saying we are having requests for water for power generation that are greater than what is projected in the plan," Brittin said. "In one basin, the inquiries were ⇨

Alternative

While we don't yet have jet-powered flying cars like the old TV cartoon *The Jetsons*, research is producing new ways to fuel our cars and to use "new" water. Even these innovations, however, must consider the energy-water connection.

Hybrid and fully electric cars are getting favorable press as green machines that save energy. They may not, however, save water, according to research done by Dr. Michael Webber and Dr. Carey King of the University of Texas (UT).

In their research, Webber and King compared the amount of water used, withdrawn, and consumed during petroleum refining and electricity generation in the United States. They estimate that plugged-in hybrid and fully electric vehicles could increase the country's water consumption with each mile driven because electricity consumes roughly two times more water than gasoline, and more than eight times more water is withdrawn to produce the electricity.

The researchers note these concerns do not necessarily mean electric cars are undesirable. "It just means there might be some tradeoffs," Webber said.

Biofuels are another research area where this energy-water nexus is apparent. The production of ethanol from corn has come under criticism because of the large amount of water needed to produce the corn. According to Webber, recent analyses indicate that the entire ethanol production cycle, from growing irrigated crops on a farm to pumping biofuels into a car, can consume 20 or more times as much water for every mile traveled than the production of gasoline.

Recognizing this, Texas AgriLife Research's bioenergy program is committed to using rain-fed crops, rather than irrigated crops, in making biofuels from different types of biomass, according to Bob Avant, bioenergy program director.

AgriLife researcher, Dr. William Rooney, professor in the Texas A&M University Soil and Crop Sciences Department, and other researchers are developing a high-tonnage, drought-tolerant sorghum for biofuel production. Researchers are also studying sugarcane and switchgrass crops.

energy must consider water needs

By Kathy Wythe

Another area of bioenergy research is using microalgae to produce biofuels. Both Texas A&M and UT have research programs on growing algae with high oil content to be used in biofuels.

Algae can grow in brackish or salty waters not suitable for drinking or irrigation so it doesn't compete with agricultural, municipalities, and other demands for freshwater resources.

Avant said AgriLife Research has partnered with General Atomics, a technology company based in San Diego, California, to develop jet fuel from microalgae at the AgriLife Research Center at Pecos. In addition to salty water, these algae strains require large amounts of sunlight and carbon dioxide to grow and produce oil, all prevalent in West Texas. "We hope to have jet fuel in three years," Avant said.

UT scientists recently created a cyanobacteria that produces cellulose and secretes glucose and sucrose that can be turned into ethanol and other biofuels, according to a UT news release. The scientists, Dr. R. Malcolm Brown Jr. and Dr. David Nobles Jr., said the microbe could provide a significant portion of the nation's transportation fuel if production can be scaled up.

David Burnett of the Global Petroleum Research Institute at Texas A&M has been working for nine years to find a way to reuse oil field-produced wastewater or brine in an effort to save fresh water and reduce associated costs. Conventional production of oil and gas generates about eight barrels of water for every barrel of oil produced, Burnett said. This water usually is re-injected into the oil reservoir.

With the start of drilling for natural gas by unconventional production methods, such as that used in the Barnett Shale in north central Texas, water has become a critical issue, Burnett said. Unconventional production not only uses more water than conventional methods, but the wastewater created during the drilling process cannot be injected back into the reservoir. Instead, it must be hauled off by trucks to another site.

By using membrane filtration and desalination process technology developed by Burnett and the petroleum institute, this wastewater can be reused in the drilling process, thus saving fresh water, reducing costs, and lowering the impact of environmentally sensitive areas. Texas A&M has recently partnered with M-I SWACO, a worldwide oil field service company, to bring this technology to the market, Burnett said.

"In the Barnett Shale, wells require from 5 million to 7 million gallons of water per well to stimulate gas production from the tight gas-containing formation," Burnett said. "If treated to remove solids and other contaminants, much of this water can be reused, avoiding the competition with communities and agriculture for fresh water.

"In the Permian Basin, fields producing from conventional formations make seven times as much water as oil, with each barrel of water requiring re-injection for disposal. In an area plagued with droughts and water shortages, the potential for reuse of purified water is clear."

Combining "new" energy with "new" water, a Texas Tech University pilot project is using wind power to desalinate brackish groundwater for the city of Seminole. According to a Texas Tech news release, the project is the first in the country to use wind power to desalinate drinking water for an inland municipality. Tech's Wind Science and Engineering Research Center and the Water Resources Center are participating in the project, which will desalinate brackish water from the Santa Rosa Aquifer through reverse osmosis with power supplied by wind turbines.

greater than the total demand in the state. That is why we did the study, to see if we could get a better handle on what those projections were going to be in the state."

In the current legislative session, Rep. Charles Anderson introduced House Bill 366 that calls for a task force to study the state's long-term demand for electric generation capacity.

In addition to integrating energy and water planning policies, conservation of both energy and water is vital, experts said.

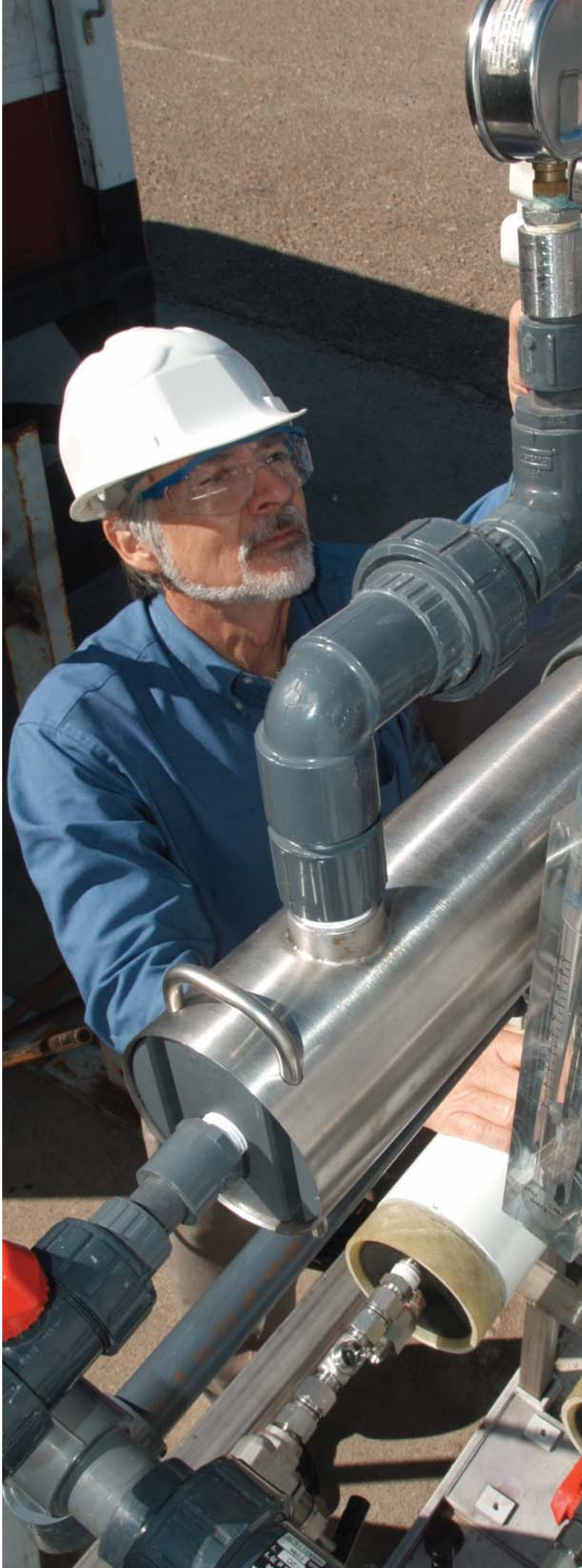
Webber suggested water-conserving solutions, such as research to develop more sophisticated ways to cool power plants with less water; use of power generators that use less water, such as wind or solar; and development of biofuels that do not require much water.

"We also need to develop less energy-intensive ways to clean water," Webber said.

Energy and water expert Bob Gary, who previously worked for TXU, now Luminant, agreed that more innovative research is needed. He said more engineers specializing in water are also essential for the necessary innovation.

Gary pointed to desalination of oil field wastewater and other saline water as one innovation that holds promise. "There is a lot of saline water scattered throughout Texas," Gary said. "If we could clean it up and use it, we would be in great shape."

He gave an example of the West Texas farmer with too little water and the West Texas oil and gas company with too much produced water. "The economics of the state needs to have the technology linked between these two industries to keep them both healthy."



1. David Burnett, director of technology for the Global Petroleum Research Institute at Texas A&M University, works on the institute's mobile desalination trailer, adjusting the feed rate of the micro filter assembly. The unit is used to desalinate oil field wastewater. Photo by Texas Engineering Experiment Station Communications.

2. Texas AgriLife Research scientists are breeding sorghum for biofuel production.
   The research effort is led by Dr. Bill Rooney, AgriLife Research plant scientist. Photo by Blair Fannin, AgriLife Communications.
3. Examples of Interrelationships Between Energy and Water.
   From *Energy Demands on Water Resources*, report to Congress.
4. Wind and solar technologies could be integral components of the energy mix because of their water and fuel independence.